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Der Präsident des Europäischen Patentamts:
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

Arlette Fiedler

A. Fiedler

DEN HAAG, [illegible]
THE HAGUE, [illegible]06/99
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Koninklijke Philips Electronics N.V.
5621 BA Eindhoven
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Record carrier, apparatus and method.

The invention pertains to a record carrier storing at least video-related user data and control data in digital form, which control data enable playback control of the user data, which control data comprises at least play control data which defines user data items which are playable, at least selection control data for enabling the user to select and control reproduction of user data and at least variable control data for operating on user and system variables.

The invention further pertains to an apparatus capable of reproducing user-data under control of control data, the user data and the control data being stored in digital form on a record carrier, which user data comprises at least video data, which control data comprises at least play control data which defines user data items which are playable and at least selection control data for enabling the user to select and control reproduction of user data items, which control data further comprise variable control data defining operations on user and system variables, which apparatus is provided with control means comprising a processor controllable by said control data. The invention further pertains to a method of reproducing user-data under control of control data, according to which method the user data and the control data are read from a record carrier on which these data are stored in digital form, which user data comprises at least video data, which control data comprises play control data, selection control data and variable control data, according to which method user data items are played under control of the play control data, according to which method the selection control data enables the user to select and control reproduction of user data items, according to which method the variable control data control operations on user and system variables.

Such a record carrier, apparatus and method are known from WO 98/09290. The play control data in the form of playlists enables the record and/or playback device to reproduce the user data in a predetermined order. Apart from video data, the user data may contain for example audio data, and data giving information about the video and/or audio data. The selection control data, in the form of selection lists enable the user to make a selection out of the available playlists by giving input to the apparatus. In addition the known apparatus can process variable control data by performing arithmetical operations and logical

tests. The variable control data enables the apparatus a further way of controlling the playback of user data at the record carrier dependent of the history of user input.

In the known record carrier the variable control data comprises a Statement List which describes operations on variables and a Conditional List which describes conditional jumps.

It is a purpose of the invention to provide means which enable more simple variable control.

For this purpose the apparatus is characterised in that the apparatus is adapted to be controlled by variable control data which comprises instructions for conditional arithmetical operations.

For this purpose the record carrier is characterised in that the variable control data comprises at least one instruction for a conditional arithmetical operation.

For this purpose the method is characterised in that the variable control data comprises instructions for conditional arithmetical operations.

The invention is based on the insight that for interactive playback of audio/visual data, the choice of what is to be played back depends on many parameters, such as the current user input, the history of user input, the region of playback etc. A plurality of the operations necessary for playback control is therefore performed conditionally. As the apparatus of the invention is adapted to be controlled by variable control data which comprises instructions for conditional arithmetical operations, the variable control data can be concise so that less memory space is required and variable control is simplified.

The conditional arithmetical operations are for example addition, subtraction, multiplication, division and modulo calculation. Whether the arithmetic operations specified in the instruction are performed depends on the outcome of a logical test.

In the record carrier of the invention, the variable control data can be clearly structured. Operations which are to be performed conditionally can be arranged in the same sequence as other operations.

Such a way of control is very suitable for educational purposes: According to instructions in the variable control data the processor can evaluating the progress of the user, for example by evaluating results of user responses upon questions presented by the apparatus. Depending on the outcome of the evaluation the system can

select ar educational session to continue with.

In a favorable embodiment the record carrier is characterised in that, the instructions are embedded in Command Lists which further comprise a Command List Header which precedes the instruction and an unconditional goto which succeeds the instruction, and which refers to a next list.

It is preferred that each Command List comprises only one instruction apart from the unconditional goto.

This embodiment is advantageous if the record carrier is to be played by an apparatus of the invention in which the same processor which interprets the play control data and the selection control data also interprets the variable control data. The header enables the processor to recognise the type of control data. The unconditional goto instruction passes control to a next list, which may be either a command list, or for example a playlist, which forms play control data or a selection list which forms selection control data.

Otherwise the apparatus of the invention can have separate processors for interpreting the variable control data and the other control data. The processors can communicate with each other via variables.

These and other aspects of the invention are described with reference to the drawing. Therein:

Figure 1 shows an embodiment of an apparatus in accordance with the invention,

Figure 2 shows the syntax of an embodiment of a Play List,

Figure 3 shows the syntax of an embodiment of a Selection List,

Figure 4 shows the syntax of an embodiment of a Command List,

Figure 5 shows the syntax of possible instructions for the Command List,

Figure 6 and 7 show the semantics of the conditional portion of these instructions,

Figure 8 shows the syntax of the portion representing arithmetical operations,

Figure 9 shows an example of a combination of Play Lists, Selection Lists and Command Lists.

An optical disc player system 10 in accordance with the invention has

been shown in Figure 1. The system 10 comprises a record carrier 1 and a record player 3. The record carrier 1 is e.g. an optical disc comprising digital audio/video/data information in an embossed information layer.

This information is to be read out by use of an optical stylus 11 (known as such) which supplies the detected data to a decoding and error correcting means 13. The decoded and error corrected data are supplied to a processor 15, which cooperates with a ROM memory 15a and a RAM memory 15b to control and operate on the data flow received from decoding and error correcting means 13. A first task of the controller 15 is to provide control signals, such as velocity control tracking and focusing control signals to the servo system 16. The servo system 16 controls the angular velocity ω of the rotating disc 1 as well as the position of the optical stylus 11 with respect to the track of the optical disc 1, which has been shown by the dotted arrow r. Further the servo system 16 controls the focusing of the optical stylus, such that the bright bundle emitted by the laser is focused on the information layer of the optical disc (which has been shown by the dotted arrow f).

A second task of the processor 15 is to control the audio and video bit stream to the dedicated decoders 21, which decode the e.g. MPEG2 coded video and audio and supply the decoded video to a display 23 and the decoded audio to a speaker or speaker system 25 (e.g. a multi channel sound system).

The information to be reproduced by the display 23 and sound system 25 is selectable by user input, which is received e.g. by direct control of selection buttons 19 of the input means 17 of the optical disc player 3 or via a remote control device 17a having selection buttons 19a. Of course, other possibilities of control are available and adequate, such as but not limited to: voice control, control via a direct link to a personal computer or via a telephone modem etc.

The processor 15 of the shown embodiment can be a relatively low power microcontroller having 1 MIPS capacity. It is possible to have the video and audio MPEG2 decoding realised by a software controlled processor 15, which then should be a high speed high power process unit equipped with adequate amounts of RAM and ROM memory 15a and 15b.

The control data stored by the record carrier comprises at least play control data, here in the form of playlists, which defines user data items which are playable, for example a plurality of user data items which are playable in sequence. The control data further comprises selection control data, here in the form of selection lists, for enabling the user to select and control reproduction of user data items. The control data further comprises

variable control data, in the form of command lists, defining operations on user and system variables.

The syntax of the playlist is shown in Figure 2, therein:

The **Play List Header** is a code which identifies the beginning of the Play List, in this example having the value $10.

The **Number Of Items (NOI)** gives the number of Play Items in this Play List. The minimum value of NOI is 1.

The **List ID** gives the List ID Number. Preferably the List ID Number is unique among all lists on the record carrier.

The **Previous List Offset** contains a reference to the list that is to be interpreted on execution of the "PREVIOUS" function.

The **Next List Offset** contains a reference to the list that is to be interpreted after interpretation of this list or on execution of the "NEXT" function.

The **Return List Offset** contains a reference to the list that is to be interpreted when the "RETURN" function is executed.

Playing Time defines the number of sectors t play from each Play Item of this Play List starting from the beginning of the item.

The **Play Item Wait Time** defines the wait time after playing each Play Item. The wait may be interrupted by a user interaction function.

Auto Pause Wait Time is the wait time at Auto Pause.

The entry **Play Item #n**, represents the number of an item to play, for example the whole or part of an MPEG Audio/Video Track, or MPEG encoded Still Pictures with optional MPEG Audio, or MPEG audio without image data.

The syntax of the Selection List is shown in Figure 3. The semantics of the entries are as follows:

The **Selection List Header** identifies the beginning of the Selection List and equals $18 in this example.

The 8-bit field **Flags** can contain a plurality of flags, for indicating for example whether Selection Area Fields are present.

The **Number Of Selections (NOS)** gives the number of selections which this list enables.

The **Base Of Selection Number (BSN)** indicates the first selection number of this list.

For the **List ID** is defined analogously as for the Play List.

Previous List Offset: See the definition of Previous List Offset of the Play List.

The **Next List Offset** is the reference to the list that is interpreted on execution of the NEXT function

Return List Offset: See the definition of Return List Offset of the Play List.

The field **Default List Offset** contains an offset to the list which is interpreted upon execution of the "Default Selection" function.

Time-out List Offset gives a reference of a list that is interpreted after Time out ie. if the wait-time has expired and no user interaction has taken place.

Wait Time for Time-out gives the duration for time-out.

Play Item Number defines the play item to be replayed when the present Selection List is interpreted.

Loop Count & Jump Timing specifies the number of times that the Play Item specified in the field Play Item Number is to be repeated, and whether said replay of said Play Item should be interrupted immediately upon user interaction or not.

Selection #N Offset represents the reference to the list that is interpreted when selection number N is selected.

The syntax of the command list is shown in Figure 4.

The semantics of the command list are as follows:

Command List Header: This field identifies the start of a Command List. The value is 0x20.

Instruction Field: This field defines the operations to be carried out by the processor. Possible instructions are set out in Figure 5.

Next List Offset: This field defines the offset to the next list to execute or play.

Figure 5 shows an overview of possible instructions for the Instruction Field of the Command List. The first byte of the command is an Opcode, and the following 4 bytes are Operands. In this Figure, the symbols i,j,k,l represent indices to a variable array. If accidently a read or write access is attempted to a reserved location of the array, the command is not executed. The symbols dddd represent a 16 bit signed constant. The symbol offs represent an offset of a next command list. The third and the fourth bit of the opcode can contain a conditional opcode cond0 or cond1. The semantics for cond0 and cond1 are set out in Figure 6 and 7 resp. An value of cond0 being equal to 01, 10 and 11 respectively means that the instruction is only performed if the condition V[i] > 0, V[i] < 0 , V[i] = 0 is fulfilled. If cond0 equals to 00 its meaning is TRUE, hence the remaining portion of the instruction is performed unconditionally. Analogously if the value of cond1 is equal to 01, 10 and 11 the instruction is only performed if the condition V[i] > V[j], V[i] < V[j] , V[i] =

V[j] is fulfilled. If cond1 equals to 00 its meaning is TRUE, hence the remaining portion of the instruction is performed unconditionally. In the table there are four main sets which are denoted by the first three bits of the operand. A first set having an opcode starting with the bits 001 comprises arithmetical and logical operations wherein V[k] and V[l] are input variables and V[j] is an output variable. The type of calculation is determined by 5 to 7 of the opcode as set out in Figure 8. Whether the operation is performed depends on the value of the conditional opcode cond0. In the present embodiment arithmetical operations are addition (ADD), subtraction (MIN), multiplication (MUL), division (DIV) and modulo (MOD). Logical operations are AND, OR and XOR.

The second set has an operand starting with the bits 010. This set of instructions comprises assignments. The instruction "010 cond0 000" provides for assignment of the value of variable V[i] to variable V[k] provided that condition cond0 is true. Likewise the instruction "010 cond1 001" provides for assignment of the value of the variable V[l] to variable V[k] if condition cond1 is true. The instruction "010 cond0 010" provides for assignment of the value of the constant dddd to variable V[j] if condition cond0 is true. The instruction "010 00 110" results in a block of variables being assigned the value dddd while the variable V[i] greater than or equal to 0. The variable currently being filled is indicated by index j--V[i]. After each assignment the variable V[i] is decreased by 1.

The third set comprise goto instructions. This set has an operand starting with the bits 100. Operands "100 cond0 000" and "100 cond0 001" respectively effectuate a jump to the command list at address "offs" if cond0 is true and if cond1 is true. Operands "100 cond0 010" effectuates a jump to the command list at address stored in variable V[j] if cond0 is true. Operands "100 cond0 100" and "100 cond1 101" effectuate a jump to the address "offs" and a decrease of the value of variable V[i] by one if respectively cond0 and cond 1 are true. The operand "100 cond0 110" effectuates a jump to the address "offs" and a decrease of the variables V[i] and V[j] by one.

The fourth set, of which the operand starts with the bits 110, comprises a wait and goto instruction. If this instruction "110 cond0 000" is performed the playback device will wait during V[j] seconds for user input. If no input has received within that time interval the control jumps to the list at address "offs".

Apart from user variables, the command list interpreter can also access system variables. By acting on system variables, the instructions in the command list can evaluate and/or influence system variables, such as the status of an overlay graphics channel, the setting of the audio channels (mute, mono, stereo, etc.). Additionally the instructions can

cause the processor to read other parameters, such as the current disc identification, the current track, the current playing time.

Figure 9 shows an example where play lists, selection lists and command lists control the replay of user data in an English language course. The processor starts interpretation with Command List #1. This command list effectuates that one or more counters indicating progress of the user are initialised. Values stored in the counters are for example a measure for the knowledge of grammar, for the usage of words, for the number of trials etc. In this example a command list may comprise a plurality of instructions. In another embodiment each list comprises only one instruction, so that in case of a sequence of commands each of the lists contains a pointer to the list having the succeeding instruction.

After the counters are initialised the control is passed to the Play List #1 indicated by the value of the pointer 30 in the field Next_List Offset of Command List #1. Upon interpretation of the play list the processor effectuates that a first English module comprising one or more Play Items (not shown) with audio and/or video data is presented to the user. After this module is finished Selection List #1 which is pointed to (31) by the Next_List Offset of Play List #1 takes over control. This Selection List points to a Play Item (not shown), which presents the user a question about the first English module. The user can respond thereto by making a choice. Dependent on the choice made by the user, control is passed to one of the Command Lists #2a, #2b or #2c via pointers 32, 33 and 34 respectively. The Command Lists evaluate the input of the user, and adapt the scores. The Next_List Offset of the Command Lists refers (35, 36 ,37) to a following Play List #2a, #2b or #2c, which effects the playback of a next English module. This next module can be succeeded by a next Selection List by which a next question is posed to the user. After a plurality of such sessions, comprising presentation of a module and the posing of a question, control is passed to a final Command List #n, which evaluates the history of user input and determines how to proceed the English language course.

Such an evaluation may for example comprise a conditional computation:

```
if (a>0) then
        R = (a+b)*(c+d)
else if (a<0) then
        R = (a-b)*(c-d)
    else
        R = a*c
    endif
```

endif.

Herein R is the result of the calculation and a, b, c, and d are variables.

Such an computation may be implemented in a Command List as follows. Presume that the variables a, b, c, d are stored in the variable registers 0, 1, 2 and 3 and that the result is stored in variable register 6. Registers 4, 5 are used for storing temporary results. The commands are shown in a mnemonic in which the abbreviation is preceded by the bits 3, 4 of the first byte of the command. In this case the commands all belong to the group of conditional calculations.

01add (0, 4, 0, 1)	"if a>0 then p = a + b"
01add (0, 5, 2, 3)	"if a>0 then q = c + d"
01mul (0, 6, 4, 5)	"if a>0 then R = p * q"
10sub (0, 4, 0, 1)	"if a<0 then p = a - b"
10sub (0, 5, 2, 3)	"if a<0 then q = c - d"
10mul (0, 6, 4, 5)	"if a<0 then R = p * q"
11mul (0, 6, 0, 2)	"if a=0 then R = a * c"

Variable control is relatively simple. No jumps are required and the computation can be described with a relatively small number of commands in comparison with a command list in which only unconditional calculations can be used.

CLAIMS:

1. Record carrier storing at least video-related user data and control data in digital form, which control data enable playback control of the user data, which control data comprises at least play control data which defines user data items which are playable, at least selection control data for enabling the user to select and control reproduction of user data and at least variable control data for operating on user and system variables, characterised in that the variable control data comprises at least one instruction for a conditional arithmetical operation.

2. Record carrier according to Claim 1, characterised in that, the instructions are embedded in Command Lists which further comprise a Command List Header which precedes the instruction and an unconditional goto which succeeds the instruction, and which refers to a next list.

3. Record carrier according to Claim 2, characterised in that each Command List comprises only one instruction apart from the unconditional goto.

4. Record carrier according to Claim 2 or 3, characterised in that the play control data is embedded in Play Lists, which Play Lists at least comprise a Play List Header as a first item and at least one Play Item representing playable user-data and at least one reference to a further List, and in that the selection control data is embedded in Selection Lists, which Selection Lists at least comprise a Selection List Header, at least one reference corresponding to a user selection, the Headers being mutually different, and wherein at least one Command List contains a reference to a Play List or a Selection List.

5. An apparatus capable of reproducing user-data under control of control data, the user data and the control data being stored in digital form on a record carrier, which user data comprises at least video data, which control data comprises at least play control data which defines user data items which are playable and at least selection control data for enabling the user to select and control reproduction of user data items, which control

data further comprise variable control data defining operations on user and system variables, which apparatus is provided with control means comprising a processor controllable by said control data, characterised in that the apparatus is adapted to be controlled by variable control data which comprises instructions for conditional arithmetical operations.

6. Apparatus according to Claim 5, characterised in that the control means comprises a single interpreter which is adapted to process the play control data, the selection control data and the variable control data sequentially.

7. Method of reproducing user-data under control of control data, according to which method the user data and the control data are read from a record carrier on which these data are stored in digital form, which user data comprises at least video data, which control data comprises play control data, selection control data and variable control data, according to which method user data items are played under control of the play control data, according to which method the selection control data enables the user to select and control reproduction of user data items, according to which method the variable control data control operations on user and system variables,
characterised in that, the variable control data comprises instructions for conditional arithmetical operations.

ABSTRACT:

Record carrier, apparatus and method.

A record carrier (1) of the invention stores at least video-related user data and control data in digital form. The control data enables playback control of the user data, which control data comprises at least play control data which defines user data items which are playable, at least selection control data for enabling the user to select and control reproduction of user data and at least variable control data for operating on user and system variables. The record carrier (1) is characterised in that the variable control data comprises at least one instruction for a conditional arithmetical operation.

Figure 1.

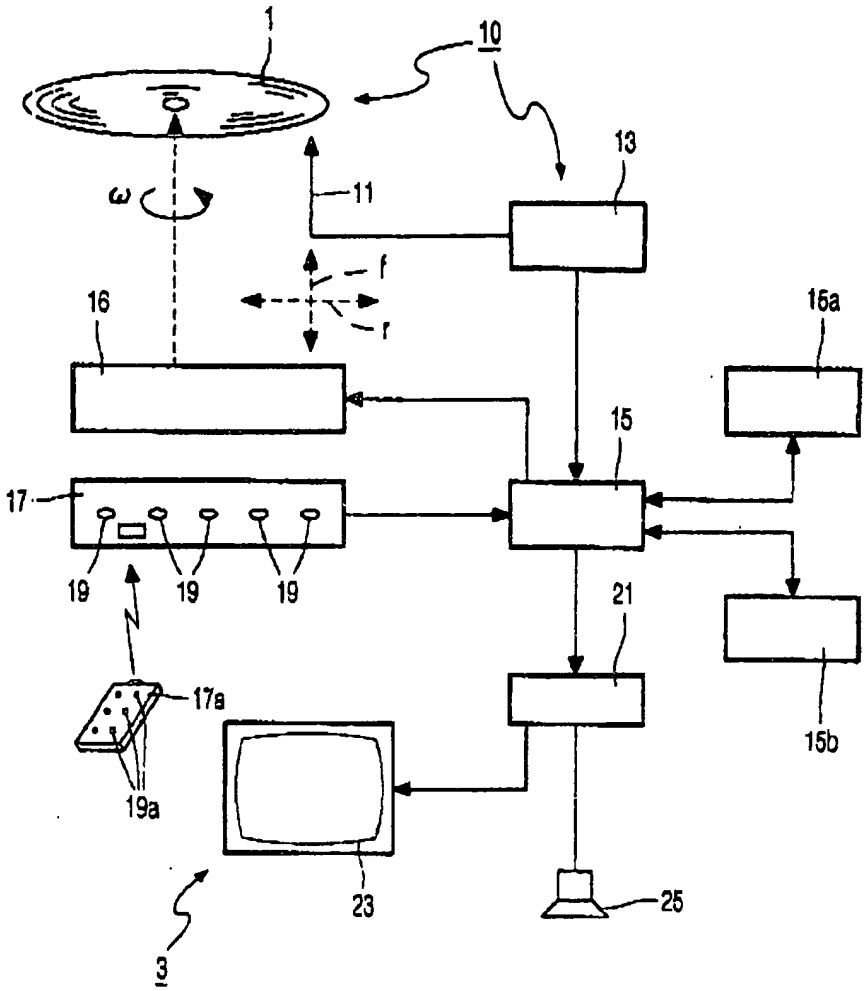

FIG. 1

Field name	Size (Bits)
Play List Header	8
Number Of Items (NOI)	8
List ID	16
Previous List Index	16
Next List Index	16
Return List Offset	16
Playing Time	16
Play Item Wait Time	8
Auto Pause Wait Time	8
Play Item #1 Number	16
•	
•	
Play Item #NOI Number	16

FIG. 2

Field name	Size (Bits)
Selection List Header	8
Flags	8
Number Of Selections (NOS)	8
Base Of Selection Number (BSN)	8
List ID	16
Previous List Offset	16
Next List Offset	16
Return List Offset	16
Default List Offset	16
Time - out List Offset	16
Wait Time for Time - out	8
Loop Count & Jump Timing	8
Play Item Number	16
Selection #BSN Offset	16
•	
•	
Selection #(BSN + NOS - 1) Offset	16

FIG. 3

Field name	Size (Bits)
Command List Header	8
Instruction	40
Next_List Offset	16

FIG. 4

Byte #1			Byte #2	Byte #3	Byte #4	Byte #5	Abbreviation and Description	
0..2	3..4	5..7						
001	cond0	calc	i	j	k	l	calc	if cond0 { V[i] : = V[k] opcode V[l] }
011	cond0	000	i	--	k	l	move0	if cond0 { V[k] : = V[l] }
	cond1	001	i	j	k	l	move1	if cond1 { V[k] : = V[l] }
	cond0	010	i	j	dd	dd	fill0	if cond0 { V[j] : = dddd }
	00	110	i	j	dd	dd	fillr	while V[i] > = 0 { V[j + V[i]] : = dddd; V[i] --}
100	cond0	000	i	--	offs	offs	jump0	if cond0 { goto offs }
	cond1	001	i	j	offs	offs	jump1	if cond1 { goto offs }
	cond0	010	i	j	--	--	return	if cond0 { goto V[i] }
	cond0	100	i	--	offs	offs	loop0	if cond0 { dec (V[i]; goto offs }
	cond1	101	i	j	offs	offs	loop1	if cond1 { dec (V[i]; goto offs }
	cond0	110	i	j	offs	offs	loop2	if cond0 { dec (V[i], V[j]; goto offs }
110	cond0	000	i	j	offs	offs	jumpw	if cond0 { wait V[i] deconds for input; goto offs }

FIG. 5

bit 3..4	Meaning
% 00	True
% 01	V[i]>0
% 10	V[I]<0
% 11	V[i]=0

FIG. 6

bit 3..4	Meaning
% 00	True
% 01	V[i]>V[j]
% 10	V[i]<V[j]
% 11	V[i]=V[j]

FIG. 7

bit 5..7	Meaning
% 000	ADD
% 001	MIN
% 010	MUL
% 011	DIV
% 100	MOD
% 101	AND
% 110	OR
% 111	XOR

FIG. 8

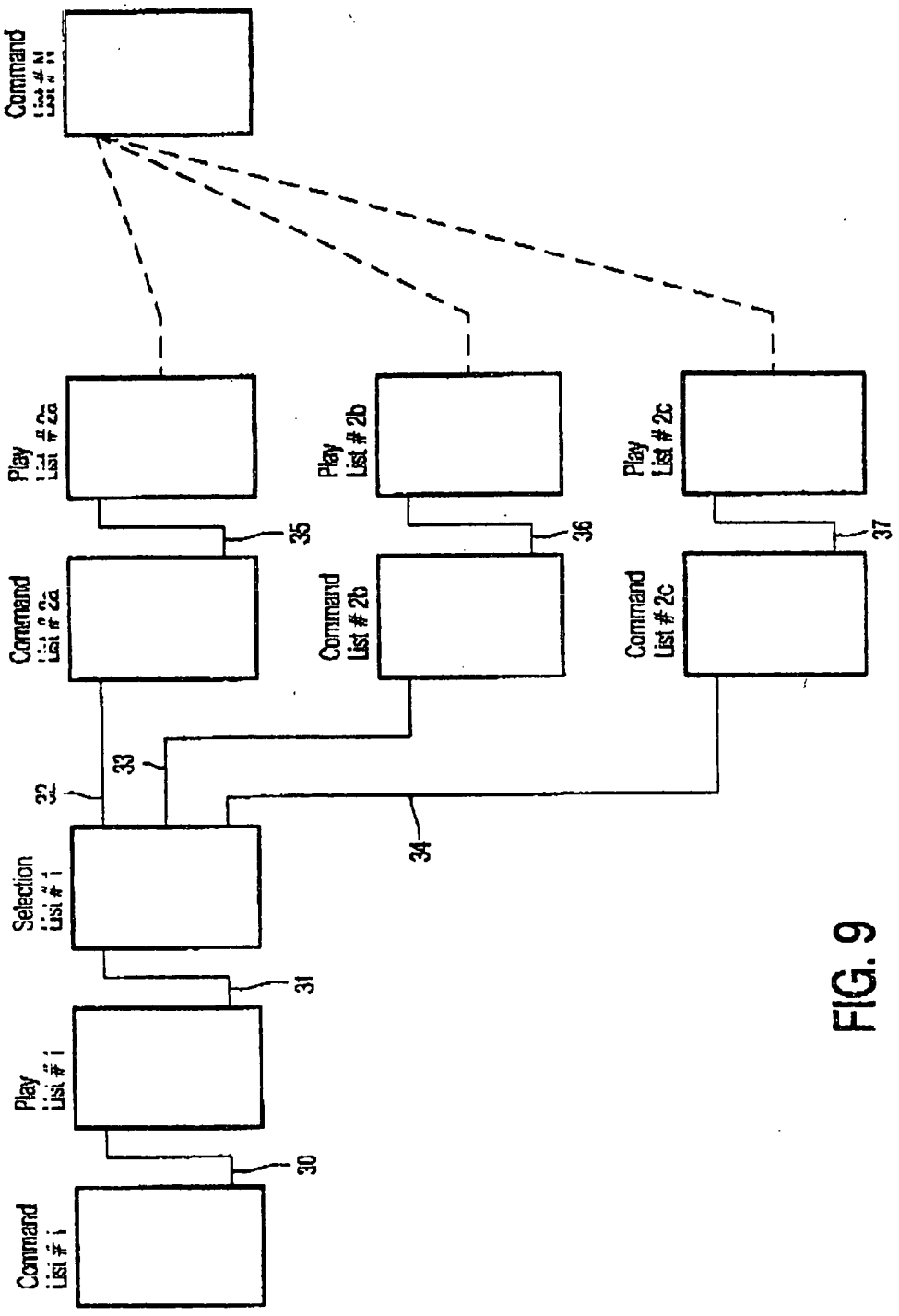
Command List # N
Play List # 2a
Play List # 2b
Play List # 2c
35
36
37
Command List # 2a
Command List # 2b
Command List # 2c
33
32
34
Selection List # 1
31
Play List # 1
30
Command List # 1

FIG. 9

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